Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

amount of faultless technique can repair or anticipate organic defects and damage wrought by months of neglect.

The problem confronting the medical profession is not only that of reducing the number in its own ranks of those who are incompetent, unfitted, careless, or criminal in the care and treatment of motherhood, but in being able to teach, through social agencies, the duty imposed upon the expectant mother, of making a scientific preparation for the ordeal—an ordeal which involves not only life for herself and her infant, but the welfare of the family. Communities must be brought to realize their responsibility in providing lying-in facilities such that no mother, in whatever social condition need suffer for lack of them.

The life of the pioneer has ever been one of hardships and perils; but with modern means of transportation, of knowledge, and of social charity, it should be possible to materially reduce the unnecessary losses which Montana has uncomprehendingly suffered in her years of development.

A SURVEY OF NATURAL ILLUMINATION IN AN INDUSTRIAL PLANT.

With Special Reference to the Use of the Indoor-Outdoor Ratio in Establishing Standards of Daylight Illumination.

By C.-E. A. WINSLOW, Professor of Public Health, Yale School of Medicine, Senior Sanitarian (R), United States Public Health Service; and LEONARD GREENBURG, Assistant Sanitary Engineer (R), United States Public Health Service.

Considerable attention has been devoted during the past few years to the study of the result of artificial illumination in factories, and adequate and satisfactory standards for judging such illumination have been prepared and placed in force.[1] So far as we are aware very little attention has been paid to the study of illumination under daylight conditions. It may, therefore, be of interest to present the results of a somewhat careful survey conducted during the war in a large munition factory in Connecticut with a special view to the development of standard procedures adapted for this type of survey.

A. GENERAL PHYSICAL CONDITIONS.

The plant in question was a large one, including nearly 150 workrooms. Its buildings were of two main types—the older ones of brick, receiving their natural illumination by means of ordinary sash windows with plain glass; the newer ones, of concrete, provided with fenestral windows of wire glass (mostly ribbed to diffuse the light as far as possible).

---

[1] Bell, Louis: Industrial Lighting Codes. J. Ind. Hyg., vol. 2, p. 183.

Since the buildings were, in general, fairly low (generally four stories) and set fairly well apart (in most cases there was approximately 40 feet between buildings), the opportunities for good daylight illumination were excellent. The comparative narrowness of the buildings was also a favorable condition. As indicated in Table I, in only 9 of the 144 shops studied was there any point over 30 feet from a window.

TABLE I.—*Workrooms classified by maximum distance from windows.*

	Maximum distance from windows, in feet.				
	15–20	21–25	26–30	31–40	41+
Number of workrooms	37	13	85	4	5

The ratio of window space to floor space, as shown in Table II, was high for the fenestral-window type of construction, but was rather low for the brick buildings with the old-type sash windows. A ratio of 0.2 may be considered as an ample allowance for fine work, and it will be noted that this value was practically always exceeded in the former case and rarely in the latter.

TABLE II.—*Workrooms classified according to ratio of window space to floor space.*

Type of window.	Ratio of window space to floor space.						
	Under 0.05	0.05–0.09	0.1–0.14	0.15–0.19	0.2–0.24	0.25–0.29	0.3 and over.
Fenestral	....	....	2	5	19	41	19
Sash	3	12	17	17	1	3	5

The windows in general were in good condition as regards cleanliness. In estimating conditions of this kind, where no quantitative objective determinations could be made, we used five arbitrary grades, namely, bad, poor, fair, good, and excellent. In 2 shops only was the cleanliness of windows rated as bad; in 7 as poor; in 29 as fair; in 57 as good; and in 49 as excellent.

B. DIRECT DETERMINATIONS OF ILLUMINATION.

Actual conditions of daylight illumination were determined in 40 typical workrooms by the use of the Macbeth Illuminometer, 402 individual observations being made. The results of these observations are presented in summary in Table III. The analysis of illumination data in such a way as to bring out general relationships is a difficult task on account of the wide variation in results obtained at different points in the same workroom, and the interpretation of conditions by means of an average value for a given workroom is almost certain to be misleading on account of the influence which may be exerted by a high reading at some single point. The method adopted in our study was to measure the illumination on working planes at from 6 to 15 different representative points in each workroom. The actual results obtained in each room are classified in Table III by convenient intervals of illumination intensity. The workrooms themselves have been divided into four groups, which we have called poor (a third or more of all observations under 2 foot-candles); fair (less than a third of all observations under 2 foot-candles); good (no observations under 2 foot-candles); and excellent (no observations under 4 foot-candles). The average results for these four groups are presented in Table IV.

TABLE III.—*Daylight illumination in 40 typical workrooms.*

Shop.	Number of observations.	Ratio, window to floor area.	Foot-candles.							
			Under 1.	1-1.9	2-3.9	4-9.9	10-19.9	20-49.9	50-99.9	100 and over.
Group I:										
1	9	0.13	....	3	4	....	2	....	....	....
2	9	.25	1	3	....	....	....	5	....	....
3	6	.02	1	2	2	1	....	....	....	....
4	9	.27	2	1	2	1	....	2	....	1
5	9	.28	4	2	2	1	....	....	....	....
6	6	.26	....	2	....	....	1	3	....	....
Group II:										
7	9	0.20	....	1	1	3	2	1	....	1
8	9	.15	1	1	....	4	2	1	....	....
9	9	.22	....	1	2	1	2	....	....	3
10	9	.25	....	1	1	2	1	3	....	1
11	9	.23	1	1	1	3	....	1	....	2
12	15	.11	1	2	....	....	4	4	1	3
13	15	.11	2	2	3	1	....	2	2	3
14	9	.12	1	....	2	....	4	2	....	....
15	14	.27	....	1	....	6	1	2	1	3
16	9	.28	....	1	2	....	2	2	1	1
17	9	.19	....	1	1	3	3	1	....	....
18	14	.26	3	....	2	1	3	1	3	1
19	9	.38	....	1	....	1	3	2	2	....
Group III:										
20	9	0.18	....	....	3	2	....	2	2	....
21	12	.09	....	....	2	3	2	2	....	3
22	9	.28	....	....	3	2	1	1	1	1
23	9	.28	....	....	2	1	3	1	1	1
24	9	.31	....	....	1	1	1	3	2	1
25	8	.28	....	....	1	....	3	2	1	1
26	16	.45	....	....	2	2	4	7	1	....
Group IV:										
27	9	0.30	....	....	....	1	1	4	....	3
28	9	.30	....	....	....	2	2	3	....	2
29	9	.30	....	....	....	1	1	4	....	3
30	9	.31	....	....	....	....	....	5	....	4
31	12	.09	....	....	....	5	1	3	1	2
32	12	.20	....	....	....	....	2	4	2	4
33	9	.18	....	....	....	1	3	3	1	1
34	9	.39	....	....	....	1	5	2	1	....
35	8	.27	....	....	....	1	3	3	....	1
36	12	.27	....	....	....	3	4	1	....	4
37	12	.28	....	....	....	1	5	1	2	3
38	11	.28	....	....	....	4	2	2	2	1
39	10	.28	....	....	....	1	4	1	2	2
40	12	.28	....	....	....	2	3	2	2	3

TABLE IV.—*Average results of illumination determinations (Table III) grouped according to degree of illumination.*

Group.	Number of rooms in group.	Number of observations.	Per cent of observations—							
			Under 1 f. c.	1-1.9 f. c.	2-3.9 f. c.	4-9.9 f. c.	10-19.9 f. c.	20-49.9 f. c.	50-99.9 f. c.	100 f. c. and over.
Poor	6	48	17	27	21	6	6	21	....	2
Fair	13	139	6	9	11	18	20	16	7	13
Good	7	72	....	....	19	15	20	25	11	10
Excellent	14	143	....	....	....	16	25	27	9	23
Total	40	402	4	6	10	15	20	22	8	15

Six workrooms fell in the first, or poorly lighted group. In this group as a whole the natural illumination is distinctly deficient, 44 per cent of all observations being under 2 foot-candles, which may be taken as a lower limit for even fairly rough manufacturing processes. The specific reason for the inadequate lighting varied widely in individual instances. One room had a ratio of window to floor space equal only to 0.02; and in addition, its windows were very near the level of the ground. Another shop had a window-to-floor ratio of only 0.13; and in addition, the light was obscured by the closeness of surrounding buildings. In the other instances window area was adequate, but the proximity of other buildings or the presence of obstructions of various sorts, casting shadows in the room, accounted for the low illumination.

The group representing the shops classed as "fair," from the standpoint of illumination, includes 13 workrooms in which a few observations were below 2 foot-candle illumination, but in which such records were exceptional, as indicated by the fact that only 15 per cent of all observations in this group fell below the limit stated.

Groups "good" and "excellent," including, respectively, 7 and 14 workrooms, seemed at all points to be amply supplied with daylight illumination during the period of our study, which was made in October, 1918.

The general showing for the whole series of 40 workrooms is an admirable one, only 10 per cent of all observations falling below 2 foot-candles, and 65 per cent being over 10 foot-candles.

C. RATIO OF INDOOR TO OUTDOOR ILLUMINATION.

Direct measurements of daylight illumination such as those described above will vary with the season of the year, the time of day, and the meteorological conditions. It can readily be seen that a strict comparison with fixed illumination standards is open to serious objections, since the results of a survey in the same shop may, even on two consecutive days, be widely different. In studying the question of natural illumination, the British Royal Commission on Lighting in Factories and Workshops (1915),[2] has attempted to find a method of making observations so as to eliminate the factor of outdoor daylight variation. They suggest the determination of the indoor illumination and the expression of this value as a percentage of the outdoor illumination, the two being obtained as nearly simultaneously as possible. The authors of the Royal Commission Report are of the opinion that this percentage is practically constant for varying conditions of outdoor illumination.

The desirability of obtaining some data on this latter point (for in the British report cited we find none) was clearly evident; and with this purpose in view, a study was made on March 12, 13, and 14, 1919, at Nathan Smith Hall in New Haven, Conn.

Conditions in and around this building were considered fairly ideal for such a study. The roof was higher than any of the surrounding roofs, and there was an unobstructed horizon in all directions. Four stations were selected in four rooms on the top floor of the building and one station on the roof. The experimental observations were made in "runs," each "run" consisting of an observation at each of the five stations, the method being to take the observations at station 1, then 2, and so on, and lastly the observation on the roof (only in one or two cases were the roof observations taken first). It is to be observed that our indoor and outdoor readings have not been made simultaneously and in this regard may be open to some criticism; but the readings were, as a rule, taken so that not more than 15 minutes elapsed between the observation at station 1 and that on the roof. Figure 1 is a graphical representation of the results obtained, and shows the variation in illumination (expressed in foot-candles) with time of day for the four indoor stations and the roof station. These diagrams clearly indicate the general correspondence in variation between the roof and indoor illumination. In only one case does there seem to be a noteworthy discrepancy in the results, namely, in the results for stations 1 and 2 on March 14. Here, it will be observed, at about 1.45 p. m. the roof lighting curve makes a sharp drop, while the curves for stations 1 and 2, on the contrary, rise. This is apparently caused by variations in the sky conditions taking place between observations. It is our belief that if our observations were made simultaneously at the indoor and roof stations such a condition would not arise. It is to be observed in this connection that the values for stations 3 and 4 correspond fairly well with the roof values. The elapsed time between observations 3 and 4 and the roof observation was about 9 minutes, whereas that between observations 1 and 2 and the roof observation was about 14 minutes.

---

[2] First Report of the Departmental Committee on Lighting in Factories and Workshops. Home Office, 1915, vol. 1, p. 38.

Turning now from the consideration of absolute to relative values, we have expressed our indoor results as percentages of the roof illumination and have plotted these for stations 1–4 in Figure 2. The curves which have the greatest interest for us are numbers 1, 3, and

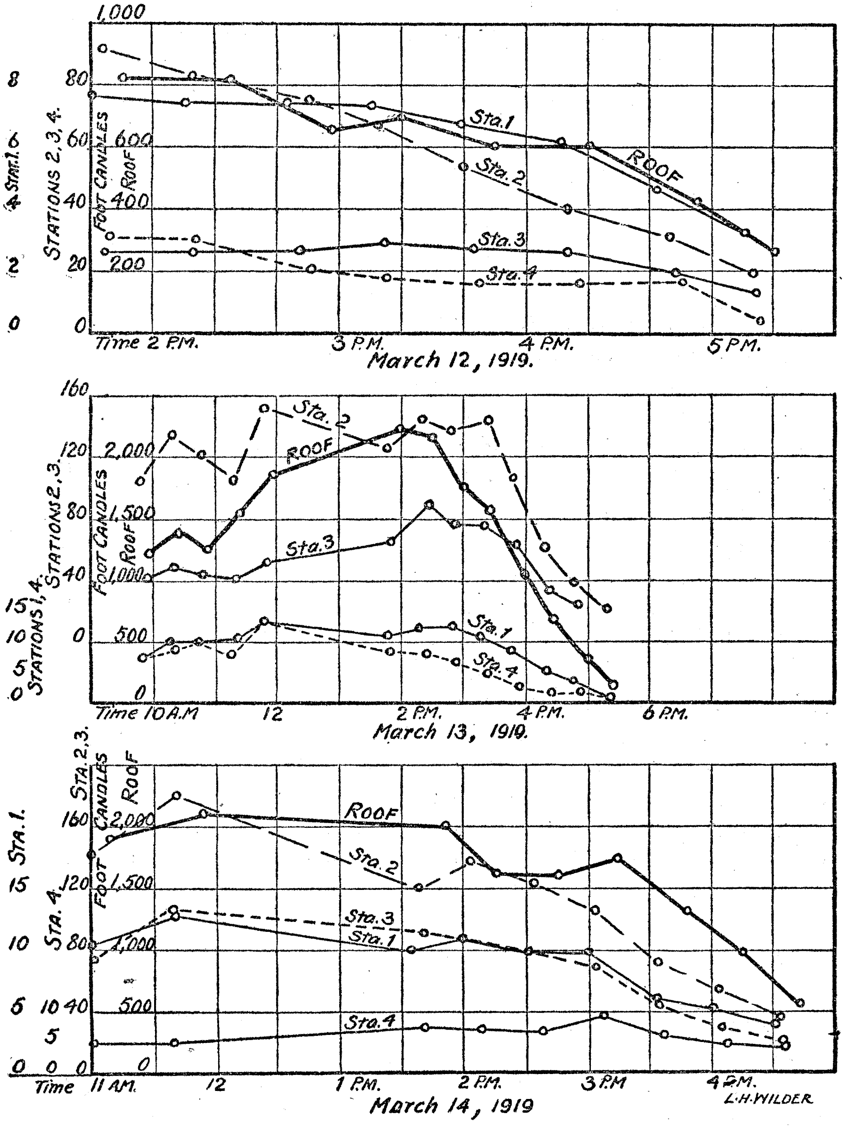

FIG. 1.—Diurnal variations in indoor and outdoor illumination (stations 1, 2, 3, and 4 indoors).

4; for these curves represent such percentages as are to be met with perhaps more often than any others in the ordinary run of shops. In the British departmental report (p. 53) we find that practically all of the observations in the engineering workshops were below 5 per cent, and a majority were below 3.5 per cent. An examination of our curves reveals the fact that they maintain themselves fairly constant with perhaps the exception of number 3 on March 13, where

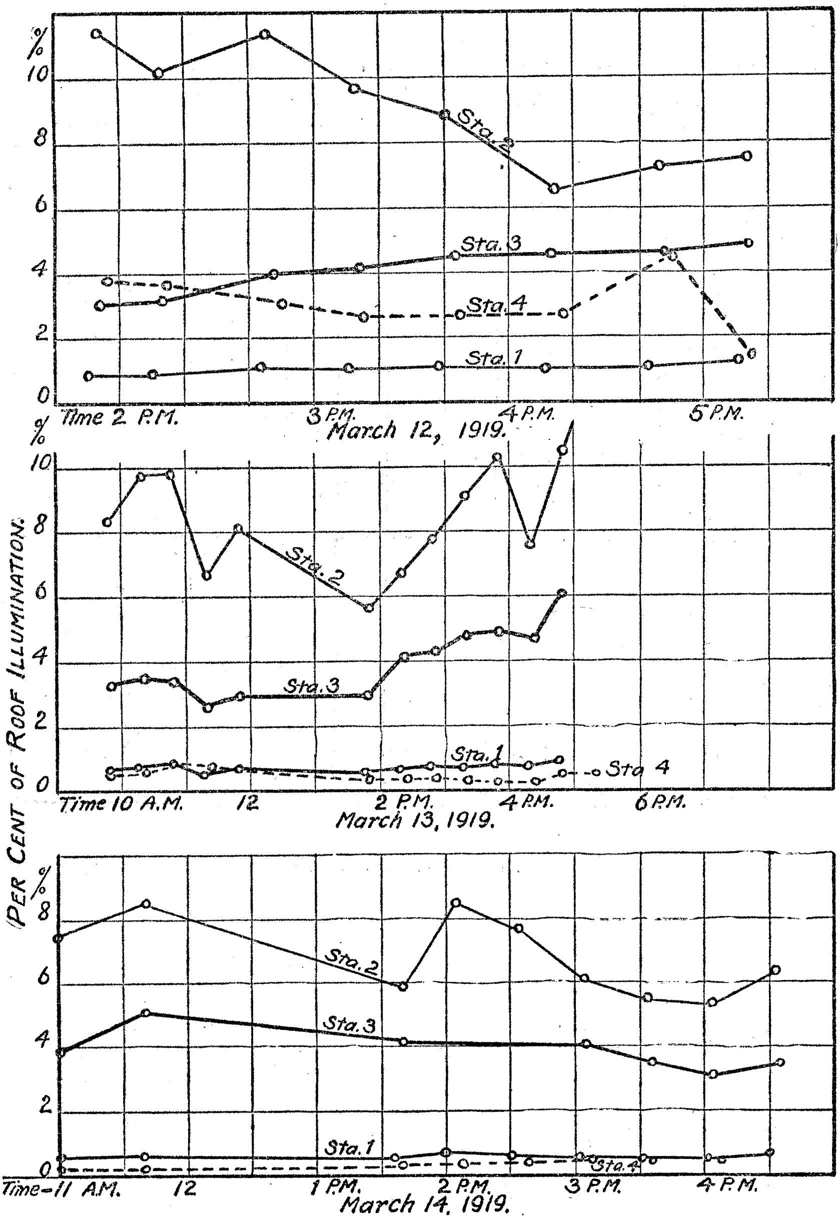

Fig. 2.—Diurnal variations in percentage of outdoor illumination recorded at various points indoors.

the curve rises from a value of 3 per cent at 2 p. m. to a value of 6 per cent at about 5 p. m. It is also to be noted that all of the curves, with one exception (No. 4 on March 12) rise gradually toward the close of the day. The reason for this may be that when the sun is nearing the horizon the rays enter the side windows, the test plate receives an additional amount of light by reflection from the walls of the room, and, hence, a smaller percentage of the direct sunlight is lost than when these rays strike directly on the roof of the building.

This last observation calls attention to a rather important source of error in the use of the indoor-outdoor ratio. The actual figure for outdoor illumination will, in general, rise more or less steadily from winter to summer and from morning to noon. In Figure 3 we have reproduced generalized curves presented by the British departmental committee illustrating this variation. The use of the indoor-outdoor ratio assumes that at all points in this curve the fraction of daylight illumination which enters a given workroom is approximately constant; but it is obvious that with a building facing east and west a much larger proportion of light will enter the east windows in the morning than in the afternoon or at noon when the sun is overhead. In such a case the indoor actual illumination is likely to diminish during the morning as the outside illumination increases, and such effects as this will be modified in varying degrees by reflection from adjacent buildings.

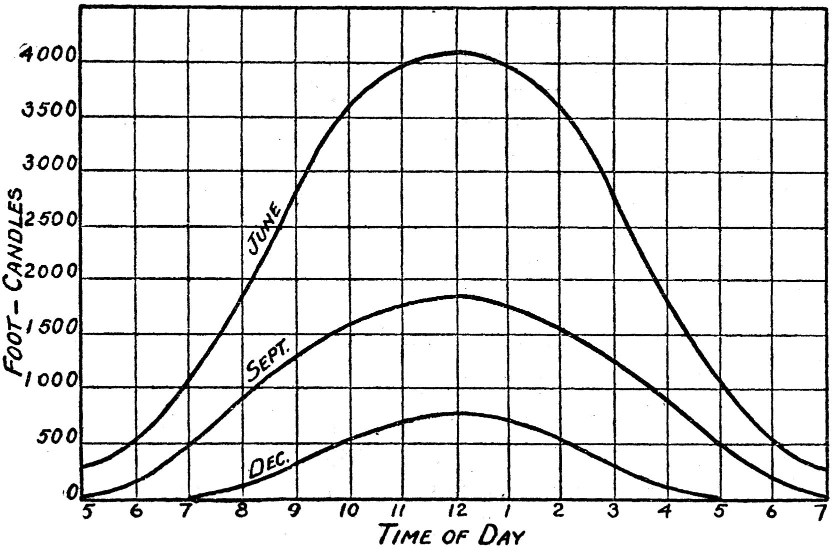

FIG. 3.—Curves showing approximate variation of daylight from 5 a. m. to 7 p. m. on average days in June, September, and December.

In spite of these limitations, however, it seems probable that the indoor-outdoor ratio is much more significant than the direct reading of indoor daylight illumination. With low indoor-outdoor ratios the effect of diurnal variations will not be great; and in a given instance a common sense interpretation of results and a checking up of actual readings and ratios will remove all serious errors.

TABLE V.—*Workrooms classified according to percentage of daylight illumination (indoor-outdoor ratio).*

Shop number.	Number of observations.	Ratio of window to floor area.	Per cent of daylight.							
			Under 0.1.	0.1–0.19	0.2–0.39	0.4–0.99	1–1.9	2–4.9	5–9.9	10+
GROUP I.										
3	6	0.02	1	3	1	1				
5	9	.28	4	3	1	1				
2	9	.25	1	1	2			5		
12	15	.11	2	4	2		1	3		3
13	15	.11	2	1		1	4	3	1	3
8	9	.15	1	1		3	2	2		
4	9	.27		2	1	3			2	1
18	14	.26		3		2	1	3	1	4
GROUP II.										
10	9	0.25		1	1	2		2	2	1
11	9	.23		1	2	2	1		1	2
14	9	.12		1		2		4	2	
19	9	.38		1		3	3	2		
1	9	.13			3	4		2		
6	6	.26			1	1		1	3	
9	9	.22			2	1	3			3
16	9	.28			1	2		3	1	2
20	9	.18			5			2	2	
7	9	.20			1	1	3	2	1	1
26	16	.45			2	2	7	4	1	
25	8	.28			1	3		3		1
GROUP III.										
17	9	0.19				2	3	3		1
23	9	.28				3		3	2	1
22	9	.28				3	2	1	1	2
24	9	.31				2		2	2	3
21	12	.09				3	2	2	2	3
40	12	.28				3	3	3		3
39	10	.28				3	2	2	2	1
38	11	.28				6	1	3		1
37	12	.28				4	3	1	2	2
GROUP IV.										
15	14	0.27					6	2	2	4
36	12	.27					3	5	1	3
32	12	.20						3	3	6
34	9	.39					1	6	1	1
35	8	.27					1	3	3	1
33	9	.18					3	3	1	2
30	9	.31					1	4		4
31	12	.09				1	4	1	3	3
27	9	.30				1	2	3		3
28	9	.30				1	2	3		3
29	9	.30				1	2	3		3

TABLE VI.—*Percentage of daylight illumination (indoor-outdoor ratio) of workrooms (Table V) grouped according to degree of illumination.*

Group.	Number of rooms.	Number of observations.	Per cent of observations in each ratio class.							
			Under 0.1.	0.1–0.19	0.2–0.39	0.4–0.99	1–1.9	2–4.9	5–9.9	10 and over.
Poor	8	86	13	21	8	13	9	19	4	13
Fair	12	111		4	17	21	15	22	12	9
Good	9	93				31	17	22	12	18
Excellent	11	112				4	22	32	13	29
Total	40	402	3	6	6	17	16	24	10.5	17.5

In Table V we have expressed in terms of the indoor-outdoor ratio the results of our 402 observations in 40 workrooms. In classifying these observations we have found it convenient to use somewhat the same relative intervals of distribution as those adopted in Table III. In computing these figures we have used in each case the actual outdoor illumination at the given time; but in order to gain an idea of what these results mean on the average, it may be stated that the mean outdoor daylight illumination during the period of our study was somewhat less than 1,000 foot-candles, so that an actual indoor illumination of 100 foot-candles would roughly correspond to over 10 per cent of the daylight illumination. In Table VI we have divided the workrooms into groups according to the ratio of indoor and outdoor illumination, classing as "poor," rooms in which one-fifth or more of all observations were under 0.2 per cent of the outdoor value; as "fair," those in which less than one-fifth of all observations were under 0.2 per cent; as "good," those in which no observations were under 0.4 per cent, but one-fifth or more were under 1 per cent; and as "excellent," the workrooms in which practically all values were over 1 per cent of the outside value.

On this basis, 8 workrooms fall into the group with poor illumination. Four of these workrooms were also in the lowest class on the basis of direct measurement. Two workrooms, however, show a fair ratio of inside to outside illumination in spite of the fact that the actual illumination on the day when it was measured in these shops was low. As a matter of fact, these shops were studied on dark days with an outdoor illumination of between 400 and 500 foot-candles.

On the other hand, four workrooms which were classed as "fair" on actual illumination show a "poor" ratio of inside to outside illumination. In three cases the outside illumination was over 700 foot-candles, and in the first two it was over 1,300 foot-candles when our measurements were made. In all four of these workrooms daylight illumination was seriously hampered by exterior or interior obstructions.

Finally, to bring out the general relationship between direct light measurements and the indoor-outdoor ratio, we have compared, in Table VII, the results obtained by the two methods.

TABLE VII.—*Comparison of results obtained by the two methods of measuring illumination.*

		Classified by indoor-outdoor ratio.				Total, direct measurement.
		Poor.	Fair.	Good.	Excellent.	
Classified by direct measurement	Poor	4	2	....	....	6
	Fair	4	7	1	1	13
	Good	....	3	4	....	7
	Excellent	....	....	4	10	14
Total, indoor-outdoor ratio		8	12	9	11	40

It is evident that the two methods of classification roughly coincide, the indoor-outdoor ratio standards adopted in Table VI being somewhat more severe than the direct illumination standards used in grouping the data of Table IV. It may be tentatively concluded that an indoor-outdoor ratio of over 0.4 per cent (our "excellent" and "good" groups) will almost always in summer give a direct illumination of over 2 foot-candles, generally a value of over 4 foot-candles. On the other hand, a workroom with an indoor-outdoor ratio often falling below 0.4 per cent (our "poor" group) is likely to show a considerable proportion of observations below 2 foot-candles. Two foot-candles of direct illumination or 0.4 per cent of the outdoor illumination at a given time may perhaps be taken as a tentative standard for general daylight illumination in such an industry as small-arms manufacture, with special illumination at particular working planes where inspection and other fine work are carried on.

D. RELATION BETWEEN BUILDING CONSTRUCTION AND DAYLIGHT ILLUMINATION.

In order to bring out the relationship between building construction and lighting results, we have once more divided the workrooms studied into three groups: (*a*) Rooms in old type brick buildings (type A) with sash windows, having in the cases studied a ratio of window space to floor space less than 0.2, the rooms being (in every case but one) less than four stories above the ground; (*b*) rooms in new concrete buildings with fenestral windows (type B), having in the cases studied a ratio of window space to floor space always over 0.2, the rooms, however, being located in the third story or below; and (*c*) rooms like those described in (*b*) but above the third story (type C). The results of our observations are summarized on this basis in Table VIII.

TABLE VIII.—*Type of building and daylight illumination (percentage of outdoor value).*

Type of building.	Number of workrooms.	Number of observations.	Per cent of observations showing various percentages of outdoor illumination.							
			Under 0.1 per cent.	0.1–0.19 per cent.	0.2–0.39 per cent.	0.4–0.99 per cent.	1–1.9 per cent.	2–4.9 per cent.	5–9.9 per cent.	10 per cent and over.
A	11	114	5	9	10	15	17	22	9	13
B	20	198	3	6	8	19	17	22	11	14
C	9	90	......	......	......	14.5	14.5	30	11	30
Total	40	402	3	5	6	17	17	24	10	18

The buildings of type B, with fenestral windows and a high ratio of window to floor space, show somewhat better results than those of type A (sash windows and low ratio of window space to floor space). In the latter type, 14 per cent of all observations show an indoor illumination equal to less than 0.2 per cent of the outdoor value, whereas 9 per cent of the observations in the buildings with fenestral windows were below this ratio. The difference is, however, much less than we had anticipated.

If the window-to-floor ratio does not appear to be highly significant in these instances, the effect of sky angle is exceedingly clear cut. It will be noted that the fenestral-window workrooms above the third floor (type C) showed in every one of 90 individual measurements over 0.4 per cent of the outdoor illumination, and in 71 per cent of these measurements over 2 per cent of the outdoor value. These higher rooms practically all enjoyed the advantage of an unobstructed sky exposure.

From this somewhat extended analysis—an analysis warranted only by the entire lack of American standards based on the indoor-to-outdoor illumination ratio and the meagerness of published results in regard even to direct daylight measurements—we may conclude that the natural illumination of this plant is, in general, excellent, 86 per cent of all observations being in excess of the tentative limit of 0.4 per cent suggested above. The illumination above the third story of the fenestral-window buildings (window to floor ratio over 0.2—sky exposure unobstructed) is practically perfect, whereas the lower stories of these same buildings (sky angle approximately 45°) show 17 per cent of all observations below 0.4 per cent, and the sash-window rooms (window-to-floor-space ratio under 0.2) in low buildings show 24 per cent of all observations below this standard.

We made no special study of the daylight glare problem in this plant; but with a few exceptions this condition was well controlled by arranging working planes at right angles to the windows, by placing machines so that the operator did not face the window when at work, and by the use of shades.

CASES OF INFLUENZA REPORTED BY STATES, 1922.

The accompanying table shows, by weeks, the number of cases of influenza reported by State health officers from January 22 to April 8, 1922.

On pages 640–641 of the Public Health Reports for March 17, 1922, appears a table giving the number of cases of influenza reported by State health officers during the first 10 weeks of the years 1920, 1921, and 1922.

The aggregate estimated population of the 29 States and the District of Columbia is approximately 67,800,000.